DO LOCAL INSTITUTIONS AFFECT ALL FOREIGN INVESTORS IN THE SAME WAY? EVIDENCE FROM THE INTERWAR CHINESE TEXTILE INDUSTRY

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DO LOCAL INSTITUTIONS AFFECT ALL FOREIGN INVESTORS IN THE SAME WAY? EVIDENCE FROM THE INTERWAR CHINESE TEXTILE INDUSTRY

This paper analyzes the impact of local employment institutions on Japanese-, British-, and Chinese-owned textile firms operating in China during the 1920s and 1930s. Though firms in Britain had higher total factor productivity (TFP) levels than firms in Japan, Japanese-owned firms in China enjoyed an approximate 70 percent TFP advantage over their British-owned and Chinese-owned competitors. The divergent performance of Japanese and British foreign direct investment (FDI) is explained by complementarity between management practices and institutional characteristics. Japanese firms had domestic experience with labor market institutions similar to those in China and used management practices that functioned well with these institutions. British firms did not face the same set of institutions domestically and used practices that were poorly suited to operation in China. The case suggests that the success of technology transfer and FDI can be contingent on institutional similarity.

I. INTRODUCTION

In the first half of the twentieth century, Japan rapidly absorbed industrial technologies from the West, while other Asian countries such as China and India lagged behind. In textiles, British managers and investors established plants in India, but productivity in these firms stagnated during the first half of the twentieth century, and many of the firms became unprofitable in the face of cheap imports from more efficient firms in Japan (Wolcott and Clark 1999). A key question in understanding twentieth century development is why Japanese firms were able to transform productivity levels in their economy, while other developing country firms, some of them run by experienced Western managers, tried and failed. To understand this puzzle, I investigate attempts of British and Japanese firms to transfer textile technology to China during the 1920s and 1930s. The analysis reveals some of the pitfalls which developed country firms face when they transfer technologies to countries with unfamiliar institutions, and explains why transfers may occur more readily across countries sharing similar backgrounds.
The process of technology transfer is often seen in deceptively simple terms: firms in developing countries learning what firms in developed countries already know. In the popular knowledge-capital model of Markusen (2004), for example, multinationals deliver knowledge of ‘best-practices’ to foreign affiliates. Whether ‘best-practices’ exist and can be transferred, however, is questionable. Some knowledge is specific to characteristics—such as factor endowments, institutions, and culture—which vary across time and place. For example, a management technique which improves productivity in one country might function poorly in a country with different characteristics. As a consequence, developing countries could potentially be better off sourcing technologies from countries with similar institutions, rather than from the world’s technological leaders.

If environmental characteristics influence the effectiveness of management practices, one would expect firms in different locations to adopt different forms of organization. Bloom, Sadun and Van Reenan (2009) observe that institutional and cultural differences across countries influence the propensity of firms to centralize management. Centralization does not break down cleanly by developmental level; for example, firms in Japan are among the world’s most centralized, while British firms are among the least. When firms set up affiliates in foreign countries, Bloom et al. (2009) find that they tend to be organized more like their parent firm than like local competitors. How foreign affiliates perform vis-à-vis local firms could depend on whether the practices they import meet local needs. In some cases, the transfer of inappropriate practices could put multinationals at a disadvantage.

I analyze transfers of organizational practices to China during the 1920s and 1930s. I focus on Japanese and British investments in Chinese textiles because their competition raises interesting questions for the theory of FDI. At this time, Japan was a relatively poor developing country and still relied on imported British textile technology. Productivity in Japan’s domestic textile sector lagged behind that in Britain; nonetheless, Japanese corporations were able to dominate British competitors in China. Between 1918 and 1936, the Japanese share of the capital stock in the Chinese spinning industry grew from 21 to 42 percent, while the British share declined from 35 to 6 percent.
Japanese success poses a puzzle: how can a change of venue allow a laggard multinational to leapfrog over a technological leader? I argue that institutional features of China favored the use of Japanese management techniques, disadvantaging firms which did not have access to this technology. A key feature of the Chinese environment was pervasive corruption. The Japanese management system was highly centralized and monitoring intensive. By contrast, the British system was decentralized and relied on pecuniary incentives rather than intense monitoring. Decentralization worked well in Britain, but in China it facilitated corruption within lower levels of the managerial hierarchy. By contrast, centralized Japanese firms restricted decision-making authority of lower-level agents, curting their corrupt behaviors.

The remainder of this paper analyzes productivity, institutions, and management practices in the Chinese textile industry in more detail. In the succeeding two sections, I use annual production statistics compiled by the Chinese Cotton Mill Owners Association and supplementary statistics describing product quality to compare TFP levels in Japanese-, British-, and Chinese-owned textile mills. The results indicate that in both spinning and weaving Japanese-owned firms were the most productive in the industry and British-owned firms among the least. The following two sections examine the effects of China’s institutional context on the operation of British-, Chinese-, and Japanese-owned mills. Building on business histories of textile corporations in China, particularly the work of Cochran (2000) and Kuwahara (1986), I first show how local employment institutions constrained the managers of British- and Chinese-owned mills and explain why the mill owners found these institutions difficult to reform. Next, I examine the organizational structure which Japanese investors imported from Japan, and explain how this structure was able to enhance labor efficiency. I identify this organizational structure as the key knowledge asset which motivated Japanese investment in Chinese textiles. The success of Japanese mill organizations inspired attempts at imitation among local competitors. In the penultimate section, I use bank investigations of organizational conditions and a case study of reforms at the largest Chinese-owned firm to show that successful reform was associated with productivity growth. Finally, I conclude by reviewing the implications of context-specific knowledge assets for international flows of investment and ideas.
II. PRODUCTIVITY IN COTTON SPINNING

Measurement of productivity in the cotton spinning industry requires adjustment for quality variation in output. Yarn fineness, or count, is the most important quality dimension.\(^1\) Pound for pound, high count yarn is much more costly to produce than low count yarn (Leunig 2003a).\(^2\) Chinese sources record mill-level information on yarn output in weight units, but typically omit mill-level information on count. Information on count is available in aggregate statistics, which show the distribution of yarn counts spun in the Japanese-, Chinese-, and British-owned sectors. These data indicate that Japanese-owned mills spun significantly higher counts than other mills. Since value-added per pound increases with count, weight-based output measures understate the relative productivity of Japanese-owned mills.

I adjust productivity for count differences using three types of statistical data on the Chinese spinning industry. The first type of data provides raw averages of labor and capital productivity in the Japanese-, Chinese-, and British-owned sectors. These sector-level averages reflect differences in both count and productivity. The second type of data provides the distribution of counts produced in the Japanese-, Chinese-, and British-owned sectors. The third type of data provides mill-level information on labor productivity, capital productivity, and count. I use these mill-level data to estimate elasticities of labor and capital productivity with respect to count. These elasticities allow comparison of

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\(^1\) A yarn’s count is defined as its length (measured in hanks) divided by its weight (measured in pounds), where a hank is a unit of length equal to 840 yards.

\(^2\) In the textile industry in modern America, doubling count approximately doubles capital costs per ton-year of capacity (Lord 2003). Count’s effect on factor requirements is important because it has caused problems in past studies of the Chinese textile industry. Clark (1988) estimates the labor productivity gap between Japanese- and Chinese-owned mills in Shanghai circa 1930 and finds (erroneously) that it was only 8 percent. Clark’s spurious findings are due to exclusion of Japanese-owned firms in Qingdao and to overestimates of the counts produced at Japanese-owned firms in Shanghai. Unadjusted data in Clark’s sources, Fong (1932) and Reynolds (1975), shows that Japanese-owned mills in Qingdao spun similar counts to Chinese-owned mills in Shanghai and, comparing these two groups, that Japanese-owned mills had 48 percent higher labor productivity circa 1930. For mills in Shanghai, Clark estimates that seven out of sixteen Japanese-owned mills produced average counts in excess of 42 in 1929, but yarn tax statistics show that Japanese-owned mills did not produce these types of yarn in 1929 (Duus 1989, Zhao and Chen 1997). Clark’s framework uses the capital-labor ratio as a proxy for labor productivity and adjusts the capital-labor ratio downwards for firms producing high counts. Since he greatly overestimates the counts spun at Japanese-owned firms in Shanghai, he greatly underestimates their productivity. For another example of the importance of count in spinning productivity estimation, see Leunig’s (2003a) criticism of productivity comparisons between Britain and the United States in Clark (1987), Broadberry (1997), and Lazonick (1981).
productivity across mills spinning different counts. Finally, I use sector-level raw averages of capital and labor productivity, my elasticity estimates, and the sector-level count distributions to calculate quality-adjusted averages of capital and labor productivity for each sector. I confirm that my quality-adjusted averages are consistent with anecdotal reports of productivity at Japanese-, Chinese-, and British-owned mills spinning specific counts. Finally, I compute TFP estimates for each sector as weighted averages of quality-adjusted capital and labor productivity.

Data on raw productivity levels come from annual statistics collected by the Chinese Cotton Mill Owners Association (CCMOA) between 1924 and 1936. These data provide the most extensive source of information on the Chinese cotton textile industry. The data record the number of workers, spindles, and looms at each mill, and the number of bales of yarn and bolts of cloth produced, together with the weight of cotton consumed. The CCMOA data suffer from a number of minor flaws. The data on yarn production sometimes exclude yarn woven into cloth. Since cotton consumption statistics do not have this problem, I use these data to measure yarn output.

Another problem is that the CCMOA data record the total number of workers at each plant, but do not indicate how workers were divided between spinning and weaving in vertically integrated mills. To deal with this problem, I use monthly plant-level surveys conducted in 1947 which provide explicit data on the number of spinning workers and weaving workers at 38 integrated mills located in Shanghai, Jiangsu, Zhejiang, and Anhui (National Survey of the Textile Industry 1947). Based on these data, I estimate that, on average, operation of one loom required 40.5 times as much labor as operation of one spindle. Based on this proportion, I infer the percentage of workers in the spinning and weaving department at each mill from spindle to loom ratios reported in the CCMOA data.

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3 The CCMOA data are available in Chinese Cotton Textile Historical Statistics (1950). English language tabulation of most of the data is available in Kraus (1980).
4 Data in Wang and Wang (1935) and the Qingdao Mill Yearbooks (1948) indicate that the ratio of yarn produced to cotton consumed was similar for all mills. Based on these data, I assume that one bale of yarn was spun for every 3.5 piculs of cotton consumed.
5 The surveys asked mills to report monthly machinery, labor, and output statistics for January-June of 1947. I collected the survey forms from the Shanghai Municipal Archive.
6 I estimate the following regression equation, where $L_i$ is the number of weaving workers per loom at mill $i$ at time $t$; $S_i$ is the number of spinning workers per spindle at mill $i$ at time $t$; $\beta$ is the ratio of labor requirements per loom to labor requirements per spindle; and $\epsilon_{it}$ is an error term:
Count differences greatly affect productivity comparisons across sectors and require a thorough analysis. Data on count differences come from Zhao and Chen (1997) and Yan (1965). These sources provide the distribution of yarn counts produced in each sector for 1929 and 1932-1935. For other years, detailed count data are unavailable and I rely on some assumptions to approximate the count distribution. Mill-level data from the *The Situation of the Jiangsu Textile Industry* (1920) and sector-level estimates from Reynolds (1975) suggest that all three sectors produced average counts of around 17.1 in the early 1920s. Accordingly, for 1924-1925, I assume that all ownership sectors produced average counts of 17.1. For the periods 1926-1928 and 1930-1931, I use linear interpolation to fill in the sector-level count distributions. For 1936, I use count distributions from 1935. Table 1 reports implied average counts for each mill group. The data show that, in most years, Japanese-owned mills spun significantly higher counts than Chinese- and British-owned mills.

The next step is to estimate elasticities that specify how capital and labor requirements varied as a function of count. My quality adjustment procedure requires these elasticities to be constant over time and across sectors. To test for elasticity variation, I estimate the elasticities using multiple cross-sectional datasets drawn from different ownership sectors, time periods, and countries. Consistency of the estimates across datasets suggests that my estimates are accurate and that the elasticities are approximately constant across sectors and over time.

For all of the samples, I use two basic estimating equations. Equation 1 specifies log labor productivity as a function of log count and control variables. Likewise, Equation

\[
\frac{\ln l_{it}}{s_{it}} = \beta + v_{it}
\]

The point estimate of \( \beta \) is 40.5, and its standard error, bootstrapped for 38 plant-level clusters, is 2.9.

\[
The conversion formula is as follows, where \( \beta \) is the average ratio of labor requirements per loom to labor requirements per spindle; \( r_i \) is the spindle to loom ratio at mill \( i \) at time \( t \); and \( p_s \) and \( p_w \) are the estimated percentages of spinning and weaving workers:
\]

\[
p_{it} = 1 - p_{it}^w = \frac{r_{it}}{r_{it} + \beta}
\]

\( 8 \) *The Situation of the Jiangsu Textile Industry* (1920) provides the counts marketed by all mills in Shanghai and Jiangsu where about two-thirds of the industry was located, but not the amount sold of each type. I estimate industry-level average count (17.1) as the unweighted average of the mill-level average counts. I calculate the mill-level average count as the unweighted average of the counts produced in each mill.
2 specifies log capital productivity as a function of the same variables. I estimate effects in two separate equations because the data rarely allow simultaneous observation of both capital and labor productivity. The levels of observation for capital and labor productivity are often different and the subscripts in Equations 1 and 2 differ accordingly. For labor productivity, I observe mill-level averages of productivity and count. These reflect the average labor productivity levels realized over the entire range of counts produced at the firm. For capital productivity, I often observe several productivity levels for each firm, each of which is associated with a specific count.

\[
\begin{align*}
    \ln l_{it} &= \beta_{0}^{l} + \varepsilon_{l,c} \ln c_{it} + \delta^{l} Z_{it} + \nu_{it} \\
    \ln k_{ijt} &= \beta_{0}^{k} + \varepsilon_{k,c} \ln c_{ijt} + \delta^{k} Z_{it} + \nu_{ijt}
\end{align*}
\]  

(1) (2)

In the two equations, \(i\) indexes firms, \(j\) indexes product types, and \(t\) indexes time; \(l_{it}\) is labor productivity at mill \(i\) at time \(t\), measured in either pounds of yarn per worker-day or pounds of yarn per unit of wage expenditure; \(k_{ijt}\) is capital productivity measured in pounds per spindle-day at mill \(i\) in product type \(j\) at time \(t\); \(c_{it}\) is the average count produced at mill \(i\) at time \(t\); \(c_{ijt}\) is the count of product type \(j\) at mill \(i\) at time \(t\); \(Z_{it}\) is a vector of control variables which vary across data sources; and \(\nu_{it}\) and \(\nu_{ijt}\) are error terms.

The coefficients of interest in Equations 1 and 2 are \(\varepsilon_{l,c}\), the elasticity of labor productivity with respect to count, and \(\varepsilon_{k,c}\), the elasticity of capital productivity with respect to count. These elasticities indicate how much additional capital and labor is required to achieve an increase in count while holding the weight of output fixed.

I estimate Equations 1 and 2 using data from two separate Chinese sources, one from 1932 and the other from 1946-1948. The first data source is a cross-section of production statistics from Chinese- and British-owned mills in seven Chinese provinces, published in Wang and Wang (1935). These statistics contain 90 machine-level observations of output per spindle-hour from 37 different mills. These data allow the precise estimation of the elasticity of capital productivity with respect to count. Information about labor usage is limited to 19 mill-level observations. Correlation between a mill’s product choices and its productivity could bias estimates of the elasticity of labor
productivity with respect to count. If more technically adept mills produce higher count yarn, then the elasticity estimate will be biased towards zero. To correct for this issue, I include the average wage rate paid at each mill as a proxy for differences in productivity. The results from these regressions, reported in Table 2, suggest that the elasticity of capital productivity with respect to count is very close to -1.15. The elasticity of labor productivity with respect to count is estimated as -0.61, but this result is imprecise and not robust. In particular, removal of the control for wages significantly decreases the magnitude of the estimated coefficient.

[Insert Table 2]

The second Chinese data source is a panel of exceptionally detailed monthly production statistics from eight government-owned mills in Qingdao operating between 1946 and 1948, as published in the company’s yearbooks. These Qingdao mills had been owned by the Japanese prior to 1945 and continued to employ Japanese managers during the late 1940s. Production conditions in the Qingdao mills were likely similar to those in Japanese-owned mills during the 1930s (Jin 2006). Data from the Qingdao Yearbooks report monthly information on wage costs in the production of each count. Assuming that workers are paid the same regardless of the count they produce, these wage data, available for July–December 1946, provide an ideal way to estimate the elasticity of labor productivity with respect to count. Other useful data in the Qingdao Yearbooks include monthly observations of yarn output per worker and the average count spun at each mill, as well as yearly product-level observations of output per spindle. This second set of observations allows the cross-sectional regressions used for the Wang and Wang (1935) dataset to be repeated in a panel setting. This is useful because the inclusion of mill fixed effects reduces the potential for correlation between count and unobserved productivity to bias the estimates. The results of these two regressions are reported in Table 3. The estimates of the elasticity of labor productivity with respect to count based on product-level wage accounts and aggregated mill-level production statistics yield similar results:

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9 Mill-level productivity variation would not bias estimates of the elasticity of capital productivity with respect to count. For capital productivity, I observe multiple counts per mill and control for cross-mill productivity variation with mill-level fixed effects.

10 I collected the Qingdao Mill Yearbooks (1948) from the Shanghai Municipal Library.
elasticities of -0.65 and -0.77, respectively. The estimate of the elasticity of capital productivity with respect to count is the same as that estimated from the Wang and Wang (1935) dataset, -1.15. I use -1.15 as my benchmark elasticity of capital productivity with respect to count.

[Insert Table 3]

The elasticity of labor productivity with respect to count is more troublesome because information in the Wang and Wang (1935) dataset is insufficient to establish a robust estimate. Estimates from the Qingdao Yearbooks are robust, but these mills might not be representative of average conditions. To confirm the external validity of the Qingdao estimates, I repeat estimates of the labor productivity elasticity using mill-level data reported in investigations by Leunig (2003a) for Britain in 1912, and by Tippet and Vincent (1953) for Britain in 1947.

The results from these regressions, reported in Table 4, are reassuring. They indicate that increases in count were also associated with a substantial increase in labor requirements. Tippet and Vincent estimated the dependency of labor requirements on count separately for the preparatory and final stages of spinning. They report that the preparatory stage accounts for 41 percent of labor hours, and the final stage accounts for 59 percent of labor hours. The estimated elasticities for the preparatory and spinning stages are -0.53 and -0.73, respectively, which yield a weighted average of -0.65, an identical value to that estimated from wage accounting information in the Qingdao Yearbooks. Leunig’s data give a substantially higher elasticity of -1.08 which suggests that increasing count may have required more additional labor in 1912 than it did in the 1940s. In what follows, I use -0.65 as my benchmark elasticity of labor productivity with respect to count. The use of -0.65 implies a smaller upwards adjustment to the productivity levels at Japanese-owned mills than the elasticities estimated from yarn output per worker information in the Qingdao Yearbooks, -0.77, or from Leunig’s data for Britain in 1912, -1.08.

[Insert Table 4]

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11The regression of count on unit wage costs can also be performed using data from the records of the largest Chinese-owned firm, Shenxin. Performing a similar regression using 66 observations of count-specific inverse wage costs at Shenxin plants operating during the mid-1930s yields an almost identical result, an elasticity of -0.66.
I combine the raw capital and labor productivity levels from the CCMOA data, the known count distributions, and the elasticity estimates to compute quality-adjusted productivity levels for each sector. I apply a standard procedure that converts raw capital and labor productivity levels into capital and labor productivity levels in terms of “20 count equivalents.” These are predictions of what capital and labor productivity levels would be if the sector produced only 20 count yarn. Computation of quality-adjusted productivity levels is shown in Equations 3 and 4, where \( h = \{ \text{Japanese, British, Chinese} \} \) indexes the sector under comparison, \( L^h \) and \( K^h \) are labor and capital productivity in sector \( h \) in terms of 20 count equivalents, \( l^h \) and \( k^h \) are unadjusted levels of labor and capital productivity in sector \( h \), \( \varepsilon_{l,c} \) and \( \varepsilon_{k,c} \) are the elasticities of labor and capital productivity with respect to count, and \( f_c^h \) is the fraction of yarn count \( c \) produced in sector \( h \), where \( c \) is one of seven possible yarn counts: 9.5, 12, 15.6, 20, 32, 42, or 60.

\[
L^h = l^h \left[ \sum_{c=9.5,12,15.6,20,32,42,60} f_c^h \left( \frac{20}{c} \right)^{\varepsilon_{l,c}} \right] : \quad 0 \leq f_c^h \leq 1 : \quad \sum f_c^h = 1 \tag{3}
\]

\[
K^h = k^h \left[ \sum_{c=9.5,12,15.6,20,32,42,60} f_c^h \left( \frac{20}{c} \right)^{\varepsilon_{k,c}} \right] : \quad 0 \leq f_c^h \leq 1 : \quad \sum f_c^h = 1 \tag{4}
\]

The raw levels of labor and capital productivity, \( l^h \) and \( k^h \), are not comparable across sectors because each sector produces a different set of products, \( \{ f_c^h \} \). Changes in this product set, \( \{ f_c^h \} \), will alter raw labor and capital productivity levels, even though the real productivity level in the sector remains fixed. I use observations of \( \{ f_c^h \} \) and estimates of the elasticities \( \varepsilon_{l,c} \) and \( \varepsilon_{k,c} \) to convert \( l^h \) and \( k^h \) into levels of capital and labor productivity in terms of a single product, 20 count yarn. The resulting values, \( L^h \) and \( K^h \), are invariant to the product set produced, allowing comparisons between sectors producing different counts.

Evaluation of Equations 3 and 4 generates capital and labor productivity series for the Chinese-, Japanese-, and British-owned sectors in terms of 20 count equivalents. Since spinning productivity figures are typically reported in terms of pounds per hour, I convert them into an hourly framework using a 320 day work-year, 24 hour operation in Chinese-

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12This 20 count equivalent procedure is standard in the literature on textiles. For example, Fujino, Fujino, and Ono (1979) convert Japanese yarn output into 20 count equivalents on the basis of value-added per pound. Similarly, Wolcott and Clark (1999) report capital and labor productivity series for the Japanese and Indian textile industries in terms of 20 count equivalents.
and British-owned mills, 22 hour operation in Japanese-owned mills, and the conversion factor of 420 pounds per bale.\textsuperscript{13} As Table 5 shows, my estimates of the productivity gap between Japanese- and Chinese-owned mills are corroborated by reports from contemporaries collected in Zhao and Chen (1997) and Duus (1989). Table 5 also reports productivity statistics for Qingdao mills in 1947 based on data in the Qingdao Yearbooks. The Qingdao Yearbooks’ data provides a useful check on the results because these data include explicit information on the counts produced, the division of workers across spinning and weaving, operating hours, and the number of days worked. Assuming that productivity did not change significantly during World War II, the Qingdao Yearbooks figures for 1947 should give estimates of capital and labor productivity in Japanese-owned mills similar to those in mid-1930s, and this is what the data show.

[Insert Table 5]

Using these adjusted labor and capital productivity figures, it is simple to produce a TFP index comparing the performance of the Japanese-, Chinese-, and British-owned sectors in spinning. Pearse (1929) reports estimates of Chinese spindle costs, labor costs, interest rates, and depreciation allowances which suggest equal spindle and labor cost shares in 20 count spinning.\textsuperscript{14} Accordingly, I calculate TFP as the exponent of the average of quality-adjusted log spindle and log labor productivity. To normalize the index, I use Wolcott and Clark’s (1999) Japanese productivity series, shown in Table 5, to estimate the average TFP level in Japan from 1930 to 1934 and use this level as a numeraire. Mills in Japan, Japanese-owned mills in China, and British- and Chinese-owned mills in China operated for 16, 22, and 24 hours a day, respectively (Pearse 1929). Shorter operating hours imposed higher capital costs on Japanese mills.\textsuperscript{15} Thus, in my TFP calculation, I adjust the

\textsuperscript{13}Data on operating hours in Chinese-, British-, and Japanese-owned mills and the pounds per bale conversion factor come from Pearse (1929).
\textsuperscript{14}Pearse (1929) estimates total capital costs for a newly constructed plant at 40 taels per spindle, and suggests 12 percent as the typical interest rate. Assuming, as in Clark (1987), the average spindle to be 25 percent depreciated, this yields average annual rental costs of 3.6 taels per spindle. Producing one bale of 20 count yarn required 1.56 spindle-years of capital input, which implies annual rental costs of 5.6 taels per bale of yarn. Pearse suggests adding 2.75 taels per bale as depreciation costs; this gives total capital costs of 8.4 taels per bale. Pearse estimates typical unit wage costs to be 9.00 taels per bale. Together, these figures imply a labor cost share of 52 percent and a capital cost share of 48 percent. These figures refer to value-added rather than total revenue.
\textsuperscript{15}Saxonhouse (1977) finds that reductions in shift length increased output per labor hour among Japanese spinning firms, indicating that reductions in labor costs partially offset increases in capital costs.
Japanese and Japanese-owned capital productivity series downwards by factors of 16/24 and 22/24, respectively. In Figure 1, I report annual TFP levels in the Japanese-, Chinese-, and British-owned sectors between 1922 and 1936 as a percentage of Japan’s benchmark TFP. During the 1930s, average TFP levels in the Japanese-, Chinese-, and British-owned sectors were 0.99, 0.59, and 0.46, respectively, indicating that the Japanese-owned sector enjoyed a large productivity advantage. In fact, at least in spinning, Japanese-owned plants located in China appear to have been just as productive as those in Japan.

[Insert Figure 1 here]

To understand China’s international competitiveness, it is useful to estimate costs of production and compare them with those of Japan, a leading textile exporter. I formulate a production cost index for 1930-1936 by adjusting the TFP index for wage differences. I use average wages among firms surveyed in Wang and Wang (1935) and records from the largest Chinese-owned firm to generate a wage series for Chinese-owned firms. I use estimates of relative wages across sectors in Duus (1989) to impute wages for the Japanese- and British-owned sectors based on the Chinese-owned series. For firms in Japan, I use a spinning wage series reported in Ramseyer (1993). I convert wage data into US dollars using annual exchange rates available in Officer (2008). The results indicate that Japanese-owned firms in China were exceptionally competitive internationally. Normalizing unit costs in Japan at 1, I estimate production costs for the Japanese-, Chinese-, and British-owned sectors as 0.79, 1.21, and 1.58, respectively.

These cost levels are consistent with the Japanese-owned sector’s export performance. While Chinese-owned firms focused on supplying low count yarns to domestic consumers, Japanese-owned firms in China exported increasing quantities of yarn.

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16 I set the Chinese nominal wage for 1930-1933 to the average hourly wage among mills surveyed by Wang and Wang in 1932-1933. From 1934 to 1936, wages fell because of depressed market conditions. I use percentage wage cuts at the Shenxin company, the largest Chinese-owned firm, to proxy for wage cuts in the Chinese-owned sector generally. Annual observations of wages at Shenxin are reported in Historical Materials on the Rong Family Enterprises (1962).

17 I calculate relative costs, $c_t$, using the following formula, where $c_{it}$ is the cost index in sector $i = \text{in Japan, Chinese-owned, Japanese-owned, British-owned}$ at time $t = 1930, ..., 1936$; $k_{it}$ is output per spindle-hour; $h_t$ is hours of firm operation per day; $l_{it}$ is output per labor-hour; $w_{it}$ is the nominal hourly wage in US dollars; and $k_t, h_t, l_t, w_t$ are simple averages of these variables across the four sectors at time $t$:

$$c_t = \frac{1}{7} \sum_{t} \frac{c_{it}}{c_{(in\ Japan)t}},$$

where $c_{it} = \frac{1}{2} \frac{k_t h_{it}}{k_{it} h_t} + \frac{1}{2} \frac{l_{it} w_{it}}{l_{it} w_t}$.
to Japan, India, and Southeast Asia. In fact, starting in 1928 and continuing until at least 1932, China exported twice as much yarn as Japan annually. Given the low costs enjoyed by Japanese-owned mills in China, it made sense to outsource yarn production to low wage Chinese labor and reserve expensive Japanese labor for weaving, where Japan continued to enjoy a comparative advantage.

As one would expect, outsourcing promoted the convergence of spinning wages in China and Japan. For Chinese labor, Japanese FDI in textiles was a great boon; employment in Japanese-owned firms provided Chinese workers the opportunity to earn wages perhaps 21 percent higher than those paid by Chinese-owned firms and 27 percent higher than those paid by British-owned firms. For Japanese labor, the contrary effect may have held. After Chinese yarn exports began to outpace Japanese yarn exports around 1928, spinning wages in Japan fell sharply; by 1936, real daily wages in Japanese spinning were only 60 percent of what they had been in 1928, and this decline was considerably larger than concurrent wage declines in agriculture and non-textile manufacturing industries.

III. PRODUCTIVITY IN WEAVING

Weaving productivity is easier to measure than spinning productivity because the CCMOA output measures (length or area) are more robust to unobserved quality differences. The most important factor increasing cloth’s value per unit of length or area is

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18 Pearse (1929) and Moser (1930) state that Chinese-owned mills produced almost exclusively for domestic consumption, whereas Japanese-owned mills exported increasing amounts of yarn. Figures are available only in 1936, when Japanese-owned mills accounted for 80 percent of Chinese exports of yarn and cloth (Chin 1937).
19 For Japanese export data, I use Seki (1956). To match CCMOA data on exports, only available prior to 1933, I measure output by weight.
20 Kuwahara (1986) finds that Japanese firms which concentrated in spinning were more likely to invest in China than integrated firms engaged in both spinning and weaving. This claim is consistent with the pattern of the Sino-Japanese textile trade during the 1930s. To provide an example, in 1934 China exported 14 million dollars of yarn (35 percent of Chinese yarn exports) to Japan, and imported 34 million dollars worth of cloth from Japan (6 percent of Japanese cloth exports) (Field 1935).
21 These figures are cited in Duus (1989). Lee (1925) estimates the wage gap between Japanese-owned and Chinese-owned firms at 5 to 15 percent. Pearse (1929) provides limited data consistent with either estimate.
22 I use Ramseyer’s (1993) series of Japanese real wages in spinning. Other phenomena affect wages, but given that, by 1936, 20 percent of Japanese-owned spinning capacity was located in China, wage competition must have exerted a strong effect.
weave density.\textsuperscript{23} Weave density is higher among mills weaving fine cloth, defined in China as cloth produced from yarns higher than 20 count (Yan 1965). Since Japanese-owned mills produced more fine cloth, area-based output measures understate their productivity.\textsuperscript{24} However, adjustments for differences in the share of fine cloth in output have only minimal effects on sector-level productivity estimates and can be omitted without substantially affecting the results.\textsuperscript{25} Accordingly, I use unadjusted units reported in the CCMOA data to measure weaving output.

The availability of a meaningful mill-level measure of output allows weaving productivity to be assessed in a simple Cobb-Douglas framework. I estimate capital and labor shares using a Cobb-Douglas production function and compute annual sector-level TFP levels from the CCMOA data based on these shares. To estimate the production function, I use data from the \textit{National Survey of the Textile Industry} (1947) and the Qingdao Yearbooks (1948) covering the period from January to June of 1947. These data sources provide monthly plant-level observations of spinning employment; weaving employment; bolts of cloth produced; weight of cotton consumed; operating shifts per month; and numbers of spindles, automatic looms, and plain looms. The combined panel covers 46 integrated spinning and weaving plants located in Shanghai, Jiangsu, Anhui, Zhejiang, and Qingdao. Twenty of these plants were Japanese-owned during the 1930s and transferred to national ownership in 1945. The remaining twenty-six plants were under private Chinese ownership.

Unlike in spinning, weaving machinery varied across sectors and this could have affected productivity. During the 1930s, Japanese-owned firms installed Toyota automatic

\textsuperscript{23}When comparing output across looms producing different cloth types, engineers often used the product of weave density and cloth length to measure output. This procedure is applied in tables in both Wang and Wang (1935) and in the Qingdao Yearbooks (1948).
\textsuperscript{24}Between 1932 and 1935, the average proportions of fine and coarse cloth woven in Japanese-, Chinese-, and British-owned mills were 27 and 73 percent, 14 and 86 percent, and 17 and 83 percent, respectively (Yan 1965).
\textsuperscript{25}Using statistics in Wang and Wang (1935) and the Qingdao Yearbooks (1948), I estimate how the share of coarse cloth in output affected capital and labor productivity. The procedure is analogous to that used in the spinning section, except that I use a coarse dummy (for capital productivity) or the share of coarse production in output (for labor productivity) as the right hand side variables. The results indicate that fine cloth required around 20 to 40 percent more labor and capital per unit of area or length than coarse cloth. Since the share of fine cloth in Japanese-owned production was 10 percent higher than that in British-owned mills, measurement in terms of area or length probably understates Japanese-owned output by about 2 to 4 percent relative to British-owned output.
looms, while Chinese- and British-owned firms continued to use cheaper plain looms (Pearse 1929; Wang 2004). Among firms in the combined 1947 sample, the share of automatic looms was 88 percent on average among formerly Japanese-owned firms, but only 28 percent among private Chinese-owned firms. To assess whether this difference affected productivity, I include the share of automatic looms in each plant’s loom stock as a control variable in production functions.

The regression specification is shown in Equation 5, where $y_{it}$ is log bolts of cloth output per weaving shift in mill $i$ at time $t$; $l_{it}$ is log weaving employment; $k_{it}$ is log looms; $s_{it}$ is the automatic loom share; $Z_{it}$ is a vector of additional controls for mill-level productivity differences; $\gamma_t$ is a set of month dummies; and $\epsilon_{it}$ is an error term.

$$y_{it} = \beta_1 k_{it} + \beta_2 l_{it} + \beta_3 s_{it} + \delta' Z_{it} + \gamma_t + \epsilon_{it}$$ (5)

Results from specifications of Equation 5, reported in Table 6, suggest that weaving production exhibited constant returns to scale with approximately equal factor shares. Specifications 1 and 2 are OLS estimations of Equation 5 which are identical except that Specification 1 omits the automatic loom share. The sample size is smaller in Specification 2 because information on loom type is missing for around one-third of the plants. In Specification 2, the estimated coefficient on the automatic looms share is positive and significant, suggesting that the use of automatics increased productivity. However, since formerly Japanese-owned mills used automatics more intensively, this result could be due to spurious correlation. Specification 3 includes a dummy variable to control for productivity differences associated with past Japanese ownership. The ownership dummy is positive and significant, and indicates that circa 1947 average TFP in formerly Japanese-owned mills was 31 log percentage points higher than that in Chinese-owned firms. The coefficient on the automatic looms share is very near zero, suggesting that the use of automatic looms did not significantly affect productivity. In Specification 4, I use within firm-variation to try to identify the productivity effects associated with automatic looms. I

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26 By 1936, about 60 percent of the looms in Japanese-owned mills were automatic (Izumi 1980). Machinery inventories in the Qingdao Yearbooks confirm that these automatic looms were the cheaper versions produced by Toyota, as opposed to the more expensive American varieties. The use of Toyota automatic looms increased capital costs by about 33 percent (Pearse 1929; Bowden and Higgins 1998). Combining these figures suggests that, in 1936, Japanese-owned capital costs (on a per loom basis) were 20 percent higher than those of Chinese- or British-owned mills.
control for firm-wide productivity levels using firm-specific time dummies and identify regression coefficients using within-firm variation across plants.\textsuperscript{27} The assumption here is that most productivity variation occurs across firms, and therefore that control for ownership reduces bias in coefficient estimates. In Specification 4, the coefficient on the automatic looms share is positive, but very small in magnitude and not statistically significant. Based on the results of Specifications 3 and 4, I conclude that any productivity advantage enjoyed by Japanese-owned firms was not due to their more widespread use of automatic looms.

A final concern, addressed in Specifications 5 and 6, is the potential for unobserved productivity differences to bias estimates of the capital and labor coefficients. Since productivity change in textiles during this period was extremely labor-saving (Clark 1987), productivity heterogeneity could bias estimates of the labor coefficient downwards and the capital coefficient upwards.\textsuperscript{28} In Specification 5, I include log labor productivity in each plant’s spinning section as a proxy for productivity in its weaving section. Comparing Specification 5 to Specification 1, inclusion of the control slightly increases the labor coefficient and slightly decreases the capital coefficient as expected. In Specification 6, I apply the Levinsohn-Pertin (2003) method which proxies for unobserved productivity differences using data on material consumption, using Levinsohn, Petrin, and Poi’s (2004) Stata algorithm. Since direct measures of yarn inputs entering the weaving process are unavailable, I use log cotton consumption and log spinning labor as proxy variables.\textsuperscript{29} The results are extremely similar to those in Specification 5, and imply constant returns to scale, a capital elasticity of around 0.45 and a labor elasticity of around 0.55.

[Insert Table 6 here]

\textsuperscript{27}Government-owned (formerly Japanese) mills in Shanghai and government-owned (formerly Japanese) mills in Qingdao were controlled by separate management organizations. I classify these as two separate multi-plant firms. Exclusion of government-owned mills from the sample does not affect the results. I drop single plant firms from the sample since they do not contribute to identification.

\textsuperscript{28}A complete analysis of weaving production technology would allow for labor-saving technological change; see for example, Bessen (2011). Introduction of a more complex production technology would not significantly affect cross-sector productivity comparisons.

\textsuperscript{29}These variables can be seen either as proxies for material inputs used in weaving, or, since they contain information about labor productivity in spinning, as measures of the mills’ technological capability in a related production process.
I use the CCMOA statistics to estimate sector-level TFP, computed as residuals of a sector-level constant-returns-to-scale Cobb-Douglas production function, with a labor share of 0.55 and a loom share of 0.45. The results shown in Figure 2, which plots aggregate TFP estimates for Japanese-, British-, and Chinese-owned plants, indicate that Japanese-owned firms enjoyed a large productivity average in weaving. From 1930-1936, Japanese-owned plants’ TFP in weaving exceeded that of Chinese-owned plants by 79 percent on average, and that of British-owned plants by 72 percent. Productivity among British-owned plants appears to collapse from 1934 to 1936, probably reflecting partial shutdowns of British-owned weaving operations. During the 1930s, many Chinese- and British-owned mills closed intermittently to reduce operating losses (Yan 1965). In computing sector-level estimates of spinning and weaving productivity, I exclude mills that completely shut down, but cannot identify mills that reduced operating hours or shut down a portion of their equipment.

[Insert Figure 2 here]

IV. EXPLAINING THE CROSS-SECTOR PRODUCTIVITY GAP

Why were Japanese-owned mills so much more productive than their competitors in spinning and weaving? Commonly cited reasons for productivity differences, such as political institutions, differences in laborers’ educational attainment and experience, and capital quality, cannot explain the performance gap because the mills operated in the same cities, using similar labor sources and machines.\(^{30}\) Similarly, evidence presented in Pearse (1929) and Fong (1932) indicates that workers in Japanese- and Chinese-owned mills had similar tenure, so that differences in worker experience do not explain the productivity gap either. Finally, the legal environment could not have driven performance differences between British and Japanese firms; most of these firms were located in Shanghai’s International Settlement, where they benefited from Western legal protections (for a discussion of Shanghai’s institutions, see Ma 2006). Moreover, if the political environment

\(^{30}\)The economic history literature on textiles suggests that machinery and worker quality differences are not plausible explanations for cross-firm productivity differences during this period. Clark (1987) notes that textile machinery was of similar quality worldwide because all machines were imported from a common set of British and American manufacturers. Leunig’s (2003b) study of New England textile workers finds that educational background had no effect on work performance and that worker experience had very minor effects.
had any effect, Chinese boycotts of Japanese products during the 1920s and 1930s and Britain’s dominant role in Shanghai’s formal governance should have disadvantaged Japanese-owned firms.

A difference which might explain poor performance in the Chinese- and British-owned sectors was their use of a form of subcontracting known as the foreperson system. Under this system, managers ceded control over labor recruitment, training, and organization to forepersons. 31 The structure of this system was quite similar to that used throughout British manufacturing. Among textile firms in Britain, forepersons were given the authority to hire their own assistants, set their wages, and make production decisions (Jewkes and Gray 1935).

Even though British firms used a similar management system both in China and at home, consequences of the system were different in the two locales. In Britain, subcontracting remained the predominant mode of manufacturing organization until well after World War II (Tolliday and Zeitlin 1991). Scholars studying British textiles have argued that subcontracting encouraged forepersons to cooperate with management to raise productivity (Lazonick 1981). Under subcontracting, British textile firms were able to produce at or near the global productivity frontier (Leunig 2003a). On the other hand, a similar system of labor arrangements in China led to frequent conflict between forepersons and management and prevented managers from making efficient hiring decisions (Cochran 2000).

The inconsistency of the results obtained under the British management system reflected differences in the British and Chinese institutional environments. In early twentieth century textiles, productivity improvement was closely linked with the intensity of labor. More productive workers tended more machines simultaneously, meaning that efficient firms had lower staffing levels. In Britain, industry-wide collective bargaining set stable piece-rates for forepersons, guaranteeing that they could earn rents if they reduced

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31 The foreperson system is described in detail by Honig (1986) and Koll (2003).
staffing levels while maintaining output. In China, labor recruitment institutions established incentives that encouraged forepersons to hire unnecessary workers.

In the Chinese labor market, bribery or ‘squeeze’ had a central role in job search. Workers obtained positions by offering forepersons sums equivalent to two weeks’ pay, and maintained employment through regular gifts. Since adding new workers increased forepersons’ income, they hired more labor than tasks demanded. Overstaffing led to considerable idleness within mills; supernumerary workers found time to loiter, sleep, and even absented themselves from the mill entirely. Clearly, to the extent that forepersons could bring idle workers into the mills, they obstructed productivity change.

The power forepersons wielded within mills reflects the influence of the Green Gang, a powerful criminal organization. Most mill labor brokers, forepersons, and guards belonged to the Gang, and membership helped them to negotiate with mill managers over hiring practices. In textiles, the Gang sold labor, property protection, and strike prevention services, but was simultaneously active in vandalism and strike instigation. Acting both as an informal union for supervisory workers and as a labor broker for unskilled workers, the Gang protested changes which disadvantaged its constituents. These disputes were often related to control over hiring and dismissals.

Progress in the textile industry depended upon reforming hiring practices to curtail bribery. However, foreperson opposition made these reforms difficult. When mills dismissed forepersons, the forepersons drew on Gang connections to mobilize worker resistance. Since workers invested in their relationships with forepersons through bribery and risked blacklisting if they abandoned the relationship, managers could not easily

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32 Interestingly, the Chinese Nationalist government attempted to install an industry-wide collective bargaining system after World War II (Jin 2006). Enthusiasm for this system among both mill managers and policymakers suggests that it may have been a more efficient system for managing industrial relations.

33 Hershatter (1986) remarks that a government-commissioned study of failing mills in Tianjin noted that foreperson-mediated employment led to the use of three times as many workers as were actually necessary.

34 Under the ‘let-go-policy’, forepersons afforded workers leave in exchange for bribes (Lee 1925).

35 Estimates of Green Gang membership are vague; Smith (2002) reports various estimates and suggests 20 percent of the labor force.


37 Barker and Barker (1934) in their investigation of mills in Shanghai and surrounding areas noted that “in China the principal trouble [in management-labor relations] is that a mill is practically forced to employ more people than is necessary and wages are only secondary in importance.”
dismiss forepersons while retaining the workers under them.\textsuperscript{38} In the event of a contested dismissal of a foreperson, the exit of shop floor workers could number in the hundreds.\textsuperscript{39} Similarly, management attempts to curtail forepersons’ right to select their own assistants brought on violent strikes.\textsuperscript{40} Given the high costs of opposition, managers usually ceded to forepersons’ demands.\textsuperscript{41}

Japanese-owned mills operated under a management structure which absorbed many of forepersons’ functions into specialized bureaucratic agencies. Personnel offices controlled hiring and the assignment of employees to tasks. Instructors trained workers in classrooms and workshops on specially designated equipment. Production decisions came under the control of trained technicians. Forepersons were essential to fewer operations, used in smaller numbers, and were paid less.\textsuperscript{42} Importantly, loss of authority over hiring, firing, and compensation decisions prevented forepersons from extracting bribes from the workforce.\textsuperscript{43}

Japanese firms’ development of centralized management structures reflected a response to problems like those in China. Firms in Japan engaged foremen (\textit{oyakata}), who controlled labor gangs, and mediated the supply, training, and management of labor. Japanese foremen mobilized patronage relationships with workers and informal networks to influence managerial decisions (Levine 1965).\textsuperscript{44} Japanese corporations responded by replacing subcontractors with corporate hierarchies that emphasized centralization, promotion-based incentives, and formal training (Jacoby 1979; Moriguchi 2003).

\textsuperscript{38} The Gang used blacklists to discipline workers who obtained jobs through improper channels. Switching between labor brokers, for example, could result in blacklisting (Honig 1983).
\textsuperscript{39} Lee (1925) gives this figure in an account of organizational conditions at Chinese- and Japanese-owned mills.
\textsuperscript{40} See the description of the strike at the Rihua mill in 1919 in \textit{The Situation of the Jiangsu Textile Industry} (1920).
\textsuperscript{41} According to Lee (1925), “… [forepersons] generally do not do much work nor know much and usually do not stay in the mills all the time. Most Chinese managers are afraid of them and would not dare to do or say anything directly against their will even when wrongdoings done by them are discovered.” (cited in Cochran 2000)
\textsuperscript{42} According to a 1920 survey of industry conditions, Japanese-owned mills used one-tenth as many supervisory personnel per production worker as Chinese-owned mills (\textit{The Situation of the Jiangsu Textile Industry} 1920).
\textsuperscript{43} Lee (1925) reports that ‘squeeze’ was limited in Japanese-owned mills, and that this angered forepersons.
\textsuperscript{44} Nimura’s (1997) analysis of conflict between labor bosses and management over technological change in the Japanese copper mining industry provides an excellent example.
with foremen mainly occurred in mining and heavy industry, but organizational responses had a broader influence on all forms of large-scale manufacturing.

Recruitment problems were an important impetus to centralization in the Japanese textile industry. In the early twentieth century, Japanese mills relied on networks of rural recruiters to supply their labor needs. Recruiters often exploited deception to arrange placements, and as a result many workers quit shortly after their arrival. Since recruitment fees were a significant component of total labor costs, turnover rates directly affected profitability. To reduce turnover, Japanese textile firms established internal recruitment offices that enhanced company control over employment contracts and worker selection.

Contrasts in the way Japanese and British investors in China approached labor management were not unique to textiles. Evidence from the coal industry suggests that problems with subcontracting were common in China generally, and that Japanese and British managers’ responses to them followed a consistent pattern. The two largest coal mining firms in early twentieth century China, Kailuan (British-owned) and Fushun (Japanese-owned), faced tremendous difficulty in managing tens of thousands of laborers, and relied on decentralized contract systems to meet their labor needs.

Agency problems made these contract systems woefully inefficient. Contractors refused to maintain mine works and used bribery and violence to usurp managerial authority.\textsuperscript{45} Unlike the British at Kailuan, the Japanese were able to transfer experience gained from the reform of contract mining systems in Japan to transform the organization of Fushun. British managers enviously noted that unlike at Kailuan, where the contract system continued to discourage innovation, at Fushun “labor management improved so much that the mines [were] able to enjoy all the benefit generated from either the innovation or improvement on coal faces” (quoted in Xu 1990). Following reforms, labor productivity at Fushun doubled, greatly surpassing performance levels at all other coal mines in China.\textsuperscript{46}

\textsuperscript{45} A digest of Kailuan company records is collected in Xu (1990). The severity of the problems described in this text is extreme. Murakushi (1981) describes the transfer of organizational techniques at Fushun mine and Wright (1981) describes the contract system in China in general.

\textsuperscript{46} This is based on output and employment series reported in Murakushi (1981) and Xu (1990). The comparison considers six year averages of labor productivity at the two largest mines in China, Fushun and Kailuan. Labor productivity levels at other mines in China were generally inferior to those obtained at these two mines (Torgashev 1930; statistics in Ikkonikov 1977). Preceding the onset of reforms in 1927, average
V. THE TRANSFER OF JAPANESE ORGANIZATIONAL PRACTICES TO CHINA

Implementation of Japanese organizational techniques in China required personnel familiar with the Chinese language and business environment. Here again, Japanese firms enjoyed major advantages over their British competitors. These advantages first emerged in long-distance trade where foreign firms’ reliance on bilingual Chinese managers gave rise to significant principal-agent problems. To eliminate these agents, Japanese trading companies set up language schools to train personnel in direct marketing and negotiation. The new personnel enabled Japanese companies to distribute textile goods at a fraction of the cost of their British competitors.\(^{47}\) Later, Japanese trading companies entered Chinese manufacturing and applied their China-specific expertise to labor management.

To understand the role of these trading companies in technology transfer, it is useful to discuss the Naigai Cotton Company, which though initially not a textile company, was the first company to export Japanese textile management techniques to China. Like all Japanese companies entering the Chinese textile industry prior to World War I, Naigai began as a general trading company (GTC).\(^{48}\) Naigai provides an excellent example of a foreign investment strategy based on country-specific knowledge rather than on technical expertise.\(^{49}\) Engaged in the textile trade, Naigai perceived an opportunity for entry into Chinese manufacturing.\(^{50}\) To acquire knowledge of textile production, Naigai bought two Japan-based plants in 1903 and 1905 to serve as training bases for the companies’

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\(^{47}\) British distribution costs were estimated to be more than triple those of Japanese textile traders in China (Yang 1984, cited in Duus 1989). See Sugiyama (2001) on direct marketing and Japanese-British competition in the Chinese sugar trade.

\(^{48}\) The first three Japanese entrants into the Chinese textile industry were Naigai, Mitsui, and Nihon Menka (Abe 2005, Odell 1916). Known as ‘the big three’, these GTCs controlled most of the Japan-China trade (Cochran 2000).

\(^{49}\) The ensuing discussion of Naigai is drawn entirely from Cochran (2000) and Kuwahara (1986).

\(^{50}\) Japan’s leading textile producers were skeptical of this move; the following quote from a Japanese economics journal provides some insight: “The productivity of the Chinese spinning industry is low…[some] think that, if one were to improve the cotton blend, renovate the machinery, train the workers properly, and modernize the management of the plant, then the results could be ameliorated. But the real reason for the poor performance of the Chinese spinning industry lies in the weather, specifically the temperature. Consequently, China is an unsuitable place for cotton spinning.” (Quoted in Kuwahara 1986)
managers, engineers, and technicians. In 1906, Naigai began transferring its specialists in Chinese wholesale trade to management positions in its Japanese plants, thus preparing them for their future work as textile managers in China. Three years later, Naigai began construction on the first of fourteen China-based plants, and recruited thirty Chinese forepersons for training in Japan. In 1911, Naigai’s first Shanghai plant opened, employing a full cohort of Japan-trained managers, engineers, technicians, and forepersons. Within two years, the results of Naigai’s novel managerial strategy were already evident: a Naigai executive noted that, “Whereas in spinning companies under Chinese or German management everything is done according to Chinese methods and confusion reigns within the mill, in this [mill] Chinese go to work under the same systematic rules that Japanese do” (quoted in Cochran 2000).

To subject workers to systematic rules, Japanese firms used central hierarchies to control key managerial functions. A key development supporting central control was the provision of formal training. Training included basic classroom education for operatives, technical education for forepersons, and professional education and training, including even financed trips to British and American institutes, for the managerial elite. This system allowed significant merit-based mobility between skill tiers.51 For instance, operatives in Japanese-owned mills, though they started at lower wages, earned raises as they passed through training programs, allowing experienced operatives to earn significantly more than was possible in other firms. International mobility was also important; experienced Japanese forepersons were often promoted to leadership positions in Chinese mills, where their status as outsiders discouraged ‘squeeze.’52 Promotion opportunities gave workers stronger incentives to comply with managerial directives.

Formal training was part of a larger system that structured information flows within Japanese-owned firms. At one such firm, the Yuhon Cotton Spinning Company, Japanese ‘process chiefs’ oversaw each step of the multi-stage spinning process. Their work was facilitated by a ‘number one’ who interpreted for the process chief and an instructor who

51 Kuwahara (1991) notes that the provision of general training supported upward mobility among Chinese workers. 52 Japanese women workers could be promoted from operative to foreperson, and then promoted again to a position in a Japanese-owned mill in China (Pearse 1929). Lee’s (1925) reports that ‘squeeze’ was absent in Japanese-owned mills because forepersons were strictly supervised by Japanese personnel.
taught new workers techniques. Unlike at Chinese-owned mills, where naive workers on
the production line disrupted organization, new hires at Yuhon obtained experience with
machines specifically devoted to training.\footnote{Kuwahara (1991) provides a brief but
detailed account of training practices at a number of Japanese-owned
mills in China, including Yuhon. Cochran (2000) describes training at Naigai.}
Below the process chief, the number one, and
the instructor stood the shop floor supervisor and the forepersons, who oversaw the
machine operatives. Although initially filled by Japanese, supervisory positions below
process chief were increasingly delegated to Chinese, many of whom received training in
Japan. Executive positions, from the process chief and upwards, were filled under a
temporary assignment system which rotated managers and engineers between China- and
Japan-based plants at regular intervals. This system enabled China-based plants to benefit
from incremental improvements to production techniques emerging from innovative
Japanese mills.

Japanese innovations were closely connected to precise control of work practices.
Leading Japanese-owned mills subjected every step of the production process to scientific
experiment, using the results to standardize work motions, time rest-breaks, and even
regulate the sleep habits of workers.\footnote{Izumi (1980) provides an example of a
questionnaire which Japanese mills used to probe the lifestyle choices of their employees, and offer them guidance on making choices which might improve their workplace performance.}
Cost accounting by product type allowed executives
to compare efficiency levels across mills, and select innovations for diffusion through the
publication of company circulars and the cross-plant transfer of personnel.\footnote{Kuwahara (2004)’s account of the Kanebo company describes the corporate structures behind these innovations.}

Interestingly, the practices and productivity advantages of Japanese-owned firms
continued when the mills were transferred to state ownership in 1945 (Jin 2006). At the
same time, private Chinese-owned firms were relatively unsuccessful in their attempts to
copy the Japanese organizational system. Evidence in the next section indicates that
foreperson resistance was the main reason for their failure.

VI. ORGANIZATIONAL REFORM UNDER OPPOSITION

Though the productivity gap between Japanese- and Chinese-owned mills was large
on average, some Chinese-owned mills made significant advances in productivity through
successful reform of the foreperson system. In other cases, attempts to modify the foreperson system led to strikes and riots, compelling would-be-reformers to leave the system in place. Successful reform generally involved significant investments, including the development of in-house training for Chinese engineers and technicians, changes in management structure that allowed technicians to directly control production, and the design of employment systems that benefited workers and reduced foreperson control. Many mills, however, adopted a more piecemeal approach, attempting only to intensify monitoring without reorganizing power structures. In these mills, forepersons used strikes and violence to derail the reform agenda. This section considers two waves of reforms, contrasting a less successful period of piecemeal change in the mid-1920s, with a more successful phase that followed in the late 1920s and early 1930s.\textsuperscript{56} In both periods, reforms were not evenly distributed throughout the textile sector; the largest two Chinese-owned firms, Shenxin and Yongan, took the lead, while many others, especially British-owned firms, did not participate. Despite these limitations, by the early 1930s reformers controlled a growing share of Chinese-owned capacity and their activities were generating productivity growth within the Chinese-owned sector.

The Shenxin Company, the largest Chinese-owned textile firm, provides an excellent case study of the reform process. Sherman Cochran (2000) has studied Shenxin in detail and I draw heavily from his analysis. I also expand on Cochran’s qualitative study by using production statistics from the CCMOA data to show that reforms at Shenxin plants conducted during the late 1920s and early 1930s significantly improved productivity. Though one company does not comprise an industry, Shenxin was at the vanguard of the Chinese-owned sector, and changes within the firm were closely watched.

The first period of reform relied heavily on labor markets as a source of new talent. In 1924 and 1925, Shenxin assigned shop floor positions to technicians recruited from Japanese-owned firms. Reform began with an experiment: managers assigned older, poorly

\textsuperscript{56} Lee (1925), describing reform attempts in the mid-1920s, records, “During the past few months a couple of Chinese managed mills had (sic) tried to introduce a new system, employ new technical men in charge, and the result was a wholesale walk-out till the management had promised them not to carry out the plan.” Lee (1930) argues that management practices in Chinese-owned mills improved during the late 1920s. Summaries of the state of the industry in 1920, when compared to plant-level investigations of benefit programs, training programs, and management practices conducted in 1932 indicate significant changes in practices between 1920 and 1932 (\textit{The Situation of the Jiangsu Textile Industry} 1920, Jincheng Bank Records 1932-1934).
performing American spindles to the new technicians, while forepersons retained control of newer British machines. By improving production methods, the technicians quickly exceeded the performance levels attained by the forepersons, convincing Shenxin’s factory manager of the need for full-scale reorganization. Technicians took control of the shop floor, directly monitoring foreperson and worker activities. Managers also established maintenance and experimental departments to address core governance deficiencies in machine upkeep and optimization. Although these policies did result in an immediate performance improvement, the change was only transient. Limited in number, technicians depended upon cooperation from subordinates to implement changes, but because technicians increased workloads and beat workers frequently, their presence was greatly resented. After several months, Shenxin’s forepersons organized a workplace riot, expelling technicians from the mill. Following negotiations, managers dismissed the technicians and reinstated the prior governance system.

Shenxin’s second period of reforms focused on educating and training technicians internally. As was characteristic of Chinese-owned firms, initial efforts to develop talent were centered on members of the company director’s extended family, many of whom were sent to textile schools abroad. Simultaneously, Shenxin developed its own educational capacity through the founding of a company professional school, the Shenxin Managerial Training Institute. Students attending the Institute’s year-long courses engaged in classroom learning under foreign-educated instructors and concurrently practiced their knowledge in the Institute’s simulated factory. In developing a central educational institution to support multi-plant operations, Shenxin followed an approach that resembled the international training routines in place in Japanese-owned mills. Centralized training at Shenxin provided a framework for the introduction of managerial innovations across

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57 Zhang (2003) describes the experiment, and states that reforms like these were common in Chinese-owned mills during the mid 1920s, but, as at Shenxin, opposition from forepersons and gangs led to their reversal.

58 Under the new management, each worker attended 25 percent more machinery; this improvement appears to have been reversed after the technicians were removed (SASS Economics Research Institute 1962).

59 SASS Economics Research Institute (1962). The use of violence has made the Shenxin case the most well-known, but organized foreperson opposition was recorded in other prominent mills as well; see Frazier (1994).
multiple plants, including accounting techniques which allowed inter-plant comparisons of unit costs.\(^{60}\)

In-house training provided the company with the capacity to reform itself. By 1933, 81 graduates had matriculated from the Institute, providing Shenxin with the nucleus of talent in middle management necessary to mount a successful reform of its Wuxi plant. This time, Shenxin’s management co-opted workers through the provision of a range of benefits, including improved housing, dining, recreation, and religious facilities, and greater voice in company governance. The company’s Wuxi campus, renamed ‘The Community of Self-Governing Workers’ because of the use of worker-elected judges to resolve labor disputes, created an autonomous social system which encouraged workers to identify their interests with those of management. Once the new system of management-labor relations had taken hold, forepersons were dismissed from the mill and replaced with technical staff. The new staff rationalized work procedures, laying off supernumerary workers and nearly doubling the machine-tending demands for those who remained. After success at Wuxi, Shenxin began to introduce reforms at other mills. At the firm’s Hankou mill, similar reforms were coupled with the introduction of literacy requirements for new workers, who entered an extensive classroom-based training program upon employment. Achievements were more limited in Shanghai where opposition from the Green Gang made it difficult to challenge the foreperson system.\(^{61}\)

Based on reform dates for individual Shenxin plants provided in Cochran (2000), I test whether reform improved spinning and weaving productivity as measured using the CCMOA data. For spinning, I estimate plant-level TFP as the residual of a constant returns-to-scale Cobb-Douglas production function with equal factor shares. I regress spinning TFP on year dummies, plant-level fixed effects, and a reform dummy variable which is equal to one in the years following reform and equal to zero in the year of reform

\(^{60}\) In 1927, a similar accounting system was also introduced at Yongan, the second largest Chinese-owned firm. Here again, foreign-educated members of the directors’ extended family and the recruitment of Shenxin personnel played a key role in the improvements (Shanghai City Textile Industry Bureau 1964).

\(^{61}\) The ‘reformed’ personnel department in one of Shenxin’s Shanghai plants was run by a prominent gangster (Frazier 2002). The Shenxin Company may have adopted a cautious reform approach in Shanghai to avoid clashing with the Green Gang (Cochran 2000).
This productivity measure is not count-adjusted, and OLS estimates of reform coefficient are biased downwards because Shenxin spun higher yarn counts than the Chinese-owned average.\textsuperscript{63} I try to control for this problem using plant fixed effects, but the coefficient could still be biased downwards since average counts at Shenxin likely increased over time.\textsuperscript{64} Measurement of weaving productivity is less problematic because changes in cloth type have less dramatic effects on output. For weaving, I compute plant-level TFP as the residual of a Cobb-Douglas production function, using 0.45 and 0.55 as the capital and labor shares. Estimates, reported in Table 7, indicate that reform dramatically improved company performance. Focusing on the fixed effects estimates reported in Specifications 1 and 3, reform increased spinning TFP by an average of 27 log percentage points, and weaving TFP by 78 log percentage points. Since Shenxin had acquired 20 percent of Chinese-owned capacity in both spinning and weaving by 1936, success of the company’s reforms contributed greatly to aggregate productivity growth in the Chinese-owned sector.

[Insert Table 7 here]

Records of the Jincheng Bank, a Shenxin creditor, indicate that banks could play an active role in encouraging organizational change. Changes at Shenxin were closely observed by Jincheng and other banks; indeed, Jincheng participated in a consortium which took a direct role in managing some of Shenxin’s underperforming Shanghai mills. Jincheng placed observers in many of its debtors’ mills, relying on periodic reports from these agents to assess creditworthiness. Under the depressed market conditions of the early 1930s, continued access to credit became conditional on the acceptance of operational changes recommended by Jincheng staff.\textsuperscript{65}

\textsuperscript{62} Based on Cochran (2000), I consider Shenxin’s Shanghai plants as reformed from 1932-1936, Shenxin’s Wuxi plant from 1933-1936, and Shenxin’s Hankou plant from 1935-1936.

\textsuperscript{63} Shenxin company records (1932-1952) for plants Nos. 1, 2, 5, 6, and 8 indicate that four out of five plants produced some quantity of 42 counts circa 1933, with one plant producing 60 counts. By contrast, among twenty-five Chinese-owned mills surveyed by Wang and Wang (1935) in 1932-1933 only eight plants produced yarn counts as high as 42, and none produced 60 count yarn.

\textsuperscript{64} Wu’s news article (1935) reports that Shenxin had recently begun producing 80 count yarn. This is technically demanding and Shenxin was probably the first Chinese-owned mill to market counts in this range.

\textsuperscript{65} In one case, plants controlled by the Baocheng Company were even repossessed. However, Jincheng does not appear to have been successful in turning these plants around. The argument is not that Jincheng had
Research conducted by the Jincheng Bank allows testing of the hypothesis that organizational change influenced productivity. In 1932, Jincheng observers conducted an investigation of 32 Chinese- and British-owned mills in Shanghai and Jiangsu. At each mill, investigators recorded the levels of capital productivity, labor productivity, product quality, and unit costs attained in spinning 20 count yarn. Unusually, these performance measures were combined with assessments of potential explanatory factors, including machinery value, managerial quality, welfare institutions, maintenance procedures, and working conditions. Machinery value in particular is important because it provides an excellent proxy for machinery quality which could potentially influence productivity.

To facilitate econometric analysis, I convert descriptive information in the Jincheng dataset into numerical codes. I use sentence-long descriptions of managerial quality, welfare institutions, and working conditions to code a dummy variable measuring each mill’s organizational quality. For 21 out of the 32 mills, I assign an organizational quality dummy equal to one; these mills had positive assessments containing words like ‘orderly’, ‘scientific’, or ‘among the best’. I assign a zero value to mills with negative assessments, described using phrases like ‘lacking order’ or ‘employing the foreperson system, and thus impossible to organize.’ For product quality, here referring to dimensions such as the yarn’s appearance and strength rather than count, I reduce simple verbal descriptions such as ‘top grade’ and ‘middle grade’ to a 4-tier numerical scale (0, 1, 2, 3). The treatment of machinery quality is also important. The bank only provides an assessment of the combined value of each mill’s spindles and looms. To generate mill-level estimates of spindle quality, I regressed the assessed value of production equipment on the total number of spindles and looms. Based on this regression, I estimate the percentage of capital value attributable to spinning equipment at each mill, and use this to estimate the average value per spindle. As one might expect, spindles owned by recently established mills had a higher estimated value than those of older mills.

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exceptional managerial knowledge, but rather that close monitoring by creditors encouraged mill managers to undertake potentially risky productivity-enhancing reforms. (Jincheng Bank Records 1932-1934; assessment of Baocheng performance after repossession based on CCMOA data)

66 I collected the evaluation forms from the Shanghai Municipal Archives.

67 Descriptions of managerial quality, welfare institutions, and working conditions are closely correlated, so that a separate analysis of each factor is infeasible.
Table 8 presents the results of a series of regressions of performance measures on spindle value and the organizational quality dummy. The regressions indicate that organizational quality had a significant impact on the performance of Chinese- and British-owned mills, regardless of the performance measure used. Improvements in organization appear to have had a more dramatic effect on labor productivity (0.29 log points) than capital productivity (0.09 log points). Well-organized mills spun significantly higher-quality yarn, suggesting that focusing only on quantity and count may miss some performance-relevant features. Although the differences are too small for statistical significance, more expensive capital equipment does appear to have been associated with slightly higher levels of capital productivity. More expensive machines were also more heavily staffed, however, meaning that the relevance of this finding for TFP is unclear.

The results from analysis of the Jincheng investigation suggest that variations in organizational practice influenced productivity levels within the Chinese- and British-owned sectors. British-owned mills were among the worst managed mills included in the survey; out of four mills whose managerial conditions were described in particularly harsh terms, two were British. Though no Japanese-owned mills were included in Jincheng’s investigation, surveys of general industry conditions conducted in 1920, 1929, and 1930 indicate that Japanese-owned mills were the best managed in China. The finding that management, and not machinery differences, were behind within-group productivity differences among Chinese-owned mills, strongly suggests that the same was true of aggregate differences between Chinese- and Japanese-owned mills. Even after nationalization following World War II, formerly Japanese-owned mills continued to be more productive than their competitors. In 1951, a Shenxin company investigation of these factories concluded that advanced training programs and management techniques, and not machinery differences, were the key factors behind their superior performance.

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68 These surveys were conducted by Pearse (1929), a representative of a British textile industry organization, Moser (1930), a US government employee, and the Chinese Cotton Mill Owners Association (The Situation of the Jiangsu Textile Industry 1920).

69 In support of this conclusion, the survey notes that formerly Japanese-owned mills that used outdated equipment attained higher productivity levels than Chinese-owned mills that used modern equipment. (Shenxin Company Publications 1951)
VII. CONCLUSION

The Chinese experience with the absorption of textile technology reveals several points of interest to students of technology transfer, foreign investment, and development. The organization of textile production in China was heavily influenced by the local institutional environment. Difficulty in negotiating local institutions caused British-owned textile firms to perform worse than Chinese-owned firms, even though they, like all firms in the industry, were operating with primarily British machines. For firms with the appropriate knowledge of how to organize Chinese labor, good results could be obtained. Japanese-owned firms, equipped with a superior understanding of the local culture, and locally-appropriate organizational techniques, were able to achieve productivity levels which approached those in Japan.

The experience of Japanese- and British-owned firms in China shows that context affects the success of technology transfer. A managerial system may be best practice in one context, but perform poorly in a different institutional and cultural environment. The implication is that knowledge may only be useful within a certain scope, defined by input characteristics. Transfers of knowledge to regions with dissimilar inputs may fail to improve productivity.

One interesting implication of the theory is that foreign direct investment follows a matching process; investors match differentiated firm-level knowledge stocks to differentiated input sources, and obtain a productivity level which reflects goodness of fit. Based on this theory, one would expect countries with similar input characteristics, for instance those sharing common cultures, to have unusually strong investment relationships. Between WWI and WWII, this appears to have been true of Japan and China. For example, between 1914 and 1923, Japanese-owned firms grew from 19 percent to 62 percent of the total number of foreign firms registered in Shanghai, China’s premier industrial center (Reynolds 1975).

Since China’s opening to foreign investment in the 1980s, investors from Hong Kong, Taiwan, and Singapore, and other overseas Chinese communities, have played a role similar to that of Japanese investors during the 1920s and 1930s. For example, Gao (2005)
estimates a gravity model of Chinese FDI and finds that Chinese ethnicity is associated with a quintupling of investment in mainland China. This quintupling accounts for 60 percent of Chinese FDI. Because of their cultural links to the mainland, investors from ethnically Chinese nations have found opportunities in China uniquely attractive. One interesting path for future work would be the identification of knowledge sources which have provided ethnically Chinese foreign investors with a competitive advantage in contemporary China.
<table>
<thead>
<tr>
<th>Year</th>
<th>Chinese-owned</th>
<th>Japanese-owned</th>
<th>British-owned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>17.8*</td>
<td>15.9*</td>
<td>18.7*</td>
</tr>
<tr>
<td>1924-1925</td>
<td>17.1''</td>
<td>17.1''</td>
<td>17.1''</td>
</tr>
<tr>
<td>1927-1928</td>
<td>16.9''</td>
<td>21.2''</td>
<td>17.1''</td>
</tr>
<tr>
<td>1929</td>
<td>16.7\o</td>
<td>25.3\o</td>
<td>17\o</td>
</tr>
<tr>
<td>1930</td>
<td>16.9''</td>
<td>25.6''</td>
<td>17.9''</td>
</tr>
<tr>
<td>1931</td>
<td>16.9''</td>
<td>25.9''</td>
<td>18.7''</td>
</tr>
<tr>
<td>1932</td>
<td>17.1*</td>
<td>25.8* [21.6]</td>
<td>19.5*</td>
</tr>
<tr>
<td>1933</td>
<td>17.3* 17.8'</td>
<td>26.3*</td>
<td>19.5* 19.3'</td>
</tr>
<tr>
<td>1934</td>
<td>16.8*</td>
<td>26.8*</td>
<td>17.3*</td>
</tr>
<tr>
<td>1935</td>
<td>17.3*</td>
<td>27.3*</td>
<td>23.2*</td>
</tr>
<tr>
<td>1936</td>
<td>17.3''</td>
<td>27.3''</td>
<td>23.2''</td>
</tr>
<tr>
<td>1947</td>
<td>----</td>
<td>24.6^</td>
<td>----</td>
</tr>
</tbody>
</table>

Table 1 reports average counts produced by each mill group. The data indicate that Japanese-owned mills spun significantly higher counts than Chinese- and British-owned mills. Data sources are distinguished as follows:

\* Calculated from an unweighted average of marketed yarn counts in *The Situation of the Jiangsu Textile Industry* (1920).

\'' Estimates based on linear interpolation.

\o Calculated from distributions of yarn counts reported in Zhao and Chen (1997).

\* Calculated from distributions of yarn counts reported in Yan (1965).

[ In 1932, productivity calculations for Japanese-owned mills are based only on mills outside of Shanghai. Estimates in Reynolds (1975) indicated that these mills spun lower counts than those in Shanghai. Thus I use the bracketed average count, taken from Reynolds (1975), in my productivity calculation for this year.

\^ Calculated from distributions of yarn counts for twenty-one Chinese- and three British-owned mills in Wang and Wang (1935).

\^ Calculated for 8 government- (formerly Japanese-) owned mills in Qingdao from the Qingdao Yearbooks (1948).
<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Log Pounds of Yarn Per Worker-Day</th>
<th>Log Output Per Spindle-Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Log Count</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.61*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.19)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1.15**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.05)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Log Wage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.91*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.33)</td>
</tr>
<tr>
<td>Range of Counts or Average Counts</td>
<td>9.5 to 24.3</td>
<td>9.5 to 24.3</td>
</tr>
<tr>
<td>Fixed Effects</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Number of Mills</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Number of Counts</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Total Observations</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>R^2</td>
<td>0.36</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Robust Standard Errors in Parenthesis; * 5% significance ** 1% significance

Table 2 presents estimations of the elasticity of labor and spindle productivity with respect to count based on cross-sectional production statistics in Wang and Wang (1935).
TABLE 3
ELASTICITY OF LABOR AND CAPITAL REQUIREMENTS WITH RESPECT TO COUNT IN FORMER JAPANESE-OWNED MILLS, 1946-1948

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Log (Inverse Unit Wage Cost)</th>
<th>Log Pounds of Yarn Per Worker-Month</th>
<th>Log Output Per Spindle-Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Count</td>
<td>-0.65** (0.06)</td>
<td>-0.77** (0.13)</td>
<td>-1.15** (0.06)</td>
</tr>
<tr>
<td>Range of Counts or Average Counts</td>
<td>8 to 60</td>
<td>17.5 to 28.4</td>
<td>8 to 80</td>
</tr>
<tr>
<td>Fixed Effects</td>
<td>N/A (data averaged across 8 mills)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Treatment of Standard Errors</td>
<td>Robust OLS</td>
<td>Plant-level Clusters</td>
<td>Plant-level Clusters</td>
</tr>
<tr>
<td>Number of Mills</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Number of Counts</td>
<td>8</td>
<td>N/A</td>
<td>13</td>
</tr>
<tr>
<td>Data Type</td>
<td>Monthly Panel</td>
<td>Monthly Panel</td>
<td>Annual Panel</td>
</tr>
<tr>
<td>Total Observations</td>
<td>28</td>
<td>232</td>
<td>141</td>
</tr>
<tr>
<td>R²</td>
<td>0.92</td>
<td>0.27</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Standard Errors in Parenthesis; ** 1% significance

Table 3 presents estimations of the elasticity of labor and spindle productivity with respect to count based on a monthly panel of production statistics from eight government-owned mills operating between 1946 and 1948 as given in the Qingdao Yearbooks (1948).
TABLE 4
ELASTICITY OF LABOR REQUIREMENTS WITH RESPECT TO COUNT IN BRITAIN

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Preparatory Stage</th>
<th>Final Stage</th>
<th>Both Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log count</td>
<td>-0.53**</td>
<td>-0.73**</td>
<td>-1.08**</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.18)</td>
<td>(0.10)</td>
</tr>
<tr>
<td>Range of Counts or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Counts</td>
<td>16-40</td>
<td>16-40</td>
<td>8-43</td>
</tr>
<tr>
<td>Number of Mills</td>
<td>43</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>Dates</td>
<td>1947</td>
<td>1947</td>
<td>1912</td>
</tr>
<tr>
<td>Total Observations</td>
<td>43</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>R²</td>
<td>0.3</td>
<td>0.54</td>
<td>0.87</td>
</tr>
<tr>
<td>Data Source</td>
<td>Tippet and Vincent (1953)</td>
<td>Tippet and Vincent (1953)</td>
<td>Leunig (2003a)</td>
</tr>
</tbody>
</table>

Robust Standard Errors in Parenthesis; ** 1% significance

Table 4 presents estimations of the elasticity of labor productivity with respect to count based data from British firms operating in 1912 and in 1947. Data from Britain in 1912 imply a larger elasticity of labor requirements with respect to count, -1.08, than Chinese data sources, -0.65. Data from Britain in 1947 separate the spinning process into two processes, preparatory and final. Weighting the preparatory and final coefficients by the share of labor used in each stage—41 percent and 59 percent, respectively—yields an overall elasticity of -0.65, which is identical to that estimated using Chinese data.
Table 5 shows that my estimates of labor and capital productivity based on CCMOA data are consistent with anecdotal reports based on investigations of small groups of mills; all figures refer to either 20 counts or 20 count equivalents. My estimates based on CCMOA data are bolded, and the corroborating evidence is distinguished as follows:

1 Zhao and Chen (1997): ratios of labor productivity in the Chinese- and Japanese-owned sectors, based on reports of relative unit costs (1924) and unit wage costs (1936) for 20 count yarn. I convert these to labor productivity ratios by adjusting for a 10 percent wage premium in the Japanese-owned sector in 1924-1925, and a 21 percent wage premium in 1936. The premiums are from Lee (1925) and Duus (1989), respectively.

' Wolcott and Clark (1999): statistics are for 20 count equivalents


[ ] My estimate of labor and spindle productivity for government-owned Qingdao mills based on the conversion of Qingdao yearbook data into 20 count equivalents. This estimate uses explicit, rather than estimated, information on labor hours.

### Table 5
CAPITAL AND LABOR PRODUCTIVITY IN CHINESE-, JAPANESE-, AND BRITISH-OWNED MILLS IN CHINA, AND IN MILLS IN JAPAN

<table>
<thead>
<tr>
<th>Location</th>
<th>Pounds Per Worker Hour</th>
<th>Pounds Per Spindle Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In China</td>
<td>In Japan</td>
</tr>
<tr>
<td>Year↓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1924-1925</td>
<td>0.75</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>(0.78)</td>
<td></td>
</tr>
<tr>
<td>1927-1928</td>
<td>0.64</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>1929</td>
<td>&lt;0.55-0.7&gt;</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1930</td>
<td>0.53</td>
<td>1.14</td>
</tr>
<tr>
<td>1931</td>
<td>0.44</td>
<td>1.15</td>
</tr>
<tr>
<td>1932</td>
<td>0.44</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1933</td>
<td>0.50</td>
<td>1.35</td>
</tr>
<tr>
<td>1934</td>
<td>0.51</td>
<td>1.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1935</td>
<td>0.50</td>
<td>1.54</td>
</tr>
<tr>
<td>1936</td>
<td>0.49</td>
<td>1.51</td>
</tr>
<tr>
<td></td>
<td>(0.46)</td>
<td></td>
</tr>
<tr>
<td>1947</td>
<td>[2.73]</td>
<td></td>
</tr>
</tbody>
</table>

\( * \) Wolcott and Clark (1999): statistics are for 20 count equivalents


\[ \text{[ ] My estimate of labor and spindle productivity for government-owned Qingdao mills based on the conversion of Qingdao yearbook data into 20 count equivalents. This estimate uses explicit, rather than estimated, information on labor hours.} \]
### TABLE 6
COBB-DOUGLAS PRODUCTION FUNCTION FOR WEAVING

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: Log Cloth Output</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(measured in bolts per shift)</td>
<td>OLS</td>
<td>LP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Looms (β_k)</td>
<td>0.53**</td>
<td>0.53**</td>
<td>0.50**</td>
<td>0.46**</td>
<td>0.44**</td>
<td>0.46*</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.14)</td>
<td>(0.13)</td>
<td>(0.12)</td>
<td>(0.14)</td>
<td>(0.22)</td>
</tr>
<tr>
<td>Log Employment (β_l)</td>
<td>0.53**</td>
<td>0.51**</td>
<td>0.46**</td>
<td>0.56**</td>
<td>0.56**</td>
<td>0.55**</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td>(0.16)</td>
<td>(0.12)</td>
<td>(0.12)</td>
<td>(0.11)</td>
<td>(0.16)</td>
</tr>
<tr>
<td>Auto Looms Share</td>
<td>0.19*</td>
<td>-0.01</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(0.10)</td>
<td>(0.10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior Japanese Ownership</td>
<td>0.31**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Spinning Labor Productivity</td>
<td>0.06</td>
<td>0.04</td>
<td>-0.04</td>
<td>0.02</td>
<td>-0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.09)</td>
<td>(0.09)</td>
<td>(0.07)</td>
<td>(0.07)</td>
<td>(0.23)</td>
</tr>
<tr>
<td>Test of CRS (β_k+β_l-1)</td>
<td>0.06</td>
<td>0.09</td>
<td>0.09</td>
<td>0.07</td>
<td>0.07</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td>(0.09)</td>
<td>(0.09)</td>
<td>(0.07)</td>
<td>(0.07)</td>
<td>(0.23)</td>
</tr>
<tr>
<td>Time Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Firm-</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specific</td>
<td></td>
<td></td>
<td>Specific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Observations</td>
<td>257</td>
<td>173</td>
<td>173</td>
<td>116</td>
<td>257</td>
<td>257</td>
</tr>
<tr>
<td>R²</td>
<td>0.78</td>
<td>0.82</td>
<td>0.84</td>
<td>0.95</td>
<td>0.81</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Standard errors are adjusted for plant-level clustering and are reported in parenthesis.

* 5% significance ** 1% significance

Table 6 reports the estimations of Cobb-Douglas production functions for weaving. The results suggest constant returns-to-scale, capital and labor shares of around 0.45 and 0.55, and that the use of automatic looms did not significantly affect productivity. Specification 3 indicates that formerly Japanese-owned firms continued to enjoy a productivity advantage under government management.
Table 7 presents a series of OLS regressions demonstrating that organizational reforms at Shenxin were associated with significant productivity improvements. The regression sample is restricted to Chinese-owned mills operating between 1929 and 1936. Production statistics are taken from the CCMOA data and organizational reforms are dated according to Cochran (2000). In both spinning and weaving, I measure plant-level log TFP as the residual of a Cobb-Douglas production function, where the capital and labor shares in spinning are 0.5 and 0.5, and in weaving 0.45 and 0.55. The coefficient on the reform dummy in Specification 2 is biased downwards because Shenxin spun higher counts than the Chinese-owned average. Specification 1 partially corrects for this problem using fixed effects, but estimates may still be biased downwards because the counts spun at Shenxin likely increased more rapidly than the Chinese-owned average.
<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>Log Output Per Worker</th>
<th>Log Output Per Spindle</th>
<th>Log Unit Cost</th>
<th>Product Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational Quality Dummy</td>
<td>0.09**</td>
<td>0.27**</td>
<td>0.07**</td>
<td>-0.08*</td>
<td>0.8*</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.09)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.35)</td>
</tr>
<tr>
<td>Log Capital Value Per Spindle</td>
<td>0.07</td>
<td>-0.07</td>
<td>0.04</td>
<td>0.06</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.10)</td>
<td>(0.03)</td>
<td>(0.05)</td>
<td>(0.70)</td>
</tr>
<tr>
<td>Log Spindles Per Worker</td>
<td>0.97**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.91</td>
<td>0.29</td>
<td>0.27</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>26</td>
<td>31</td>
</tr>
</tbody>
</table>

Robust standard errors are reported in parentheses. * 5% significance ** 1% significance

Table 8 presents a series of OLS regressions demonstrating that well-organized mills had significantly higher output per worker, output per spindle, and product quality, and significantly lower unit costs. The data is taken from the Jincheng Bank Records (1932-1934) and the statistics refer to 20 count yarn production.
Figure 1 displays TFP indexes for the Japanese-, Chinese-, and British-owned sectors. TFP levels are reported as a percentage of the estimated average TFP in spinning in Japan in 1930-1934. The indexes are quality adjusted, based on differences in factor requirements as a function of count. With the exception of 1932, the aggregated indexes include all mills for which output data is available in CCMOA statistics. In 1932, the Shanghai Incident forced Japanese-owned mills in Shanghai to repatriate Japanese employees and close temporarily, and thus the 1932 Japanese series includes only mills in Qingdao and Wuhan.
Figure 2 displays indices of sector-level TFP in weaving, where TFP is computed as the residual of a sector-level Cobb-Douglas production function with capital and labor weights of 0.45 and 0.55, respectively. I normalize the TFP indices by setting Chinese-owned TFP in 1928 equal to one. The results show that Japanese-owned firms were dramatically more productive than Chinese- and British-owned firms. With the exception of 1932, the aggregated indexes include all mills for which output data is available in CCMOA statistics. In 1932, the Shanghai Incident forced Japanese-owned mills in Shanghai to repatriate Japanese employees and close temporarily, and thus the 1932 Japanese series includes only mills in Qingdao and Wuhan.
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